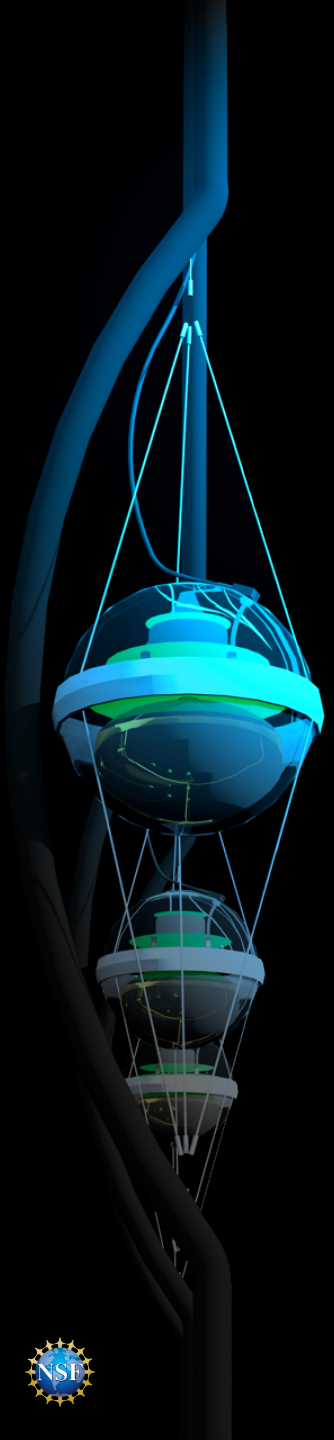
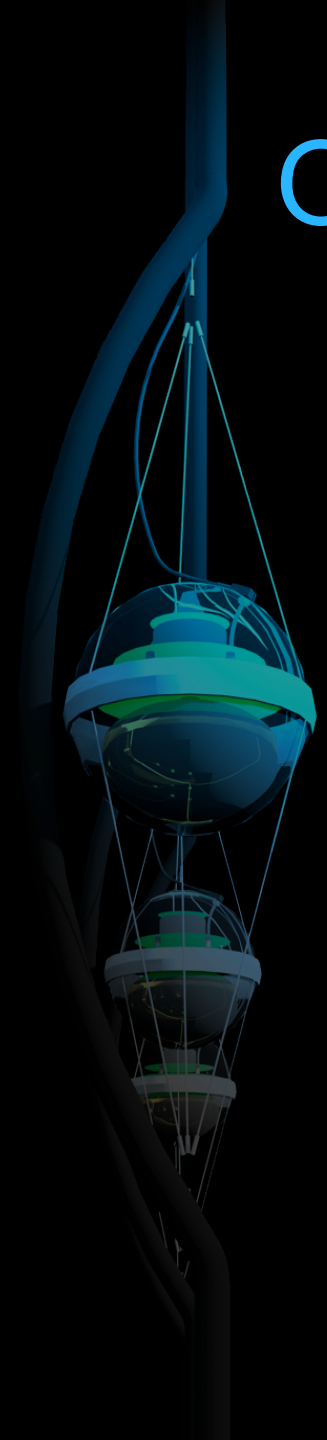


The IceCube Computing Model

Steve Barnet

University of Wisconsin – Madison

IceCube Collaboration



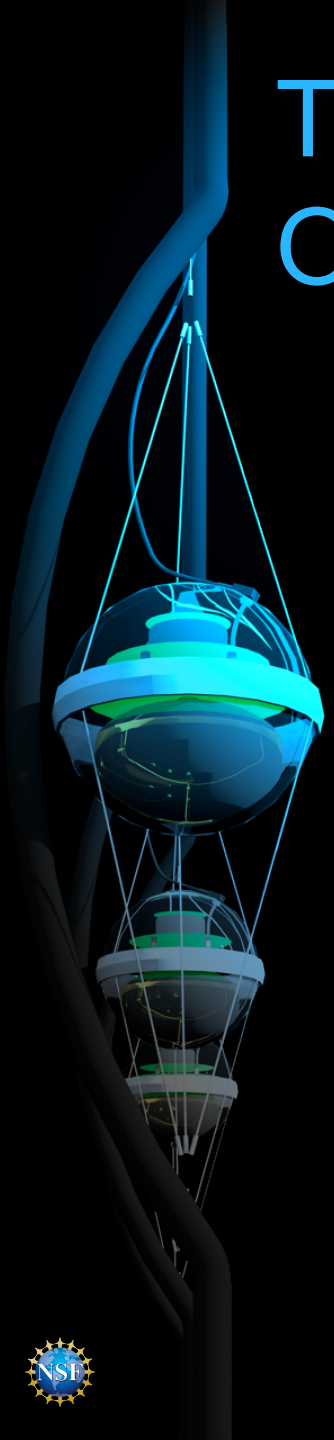
Overview

- The Basics of IceCube
- Data Handling
- Computing Model
- Summary

What is IceCube?

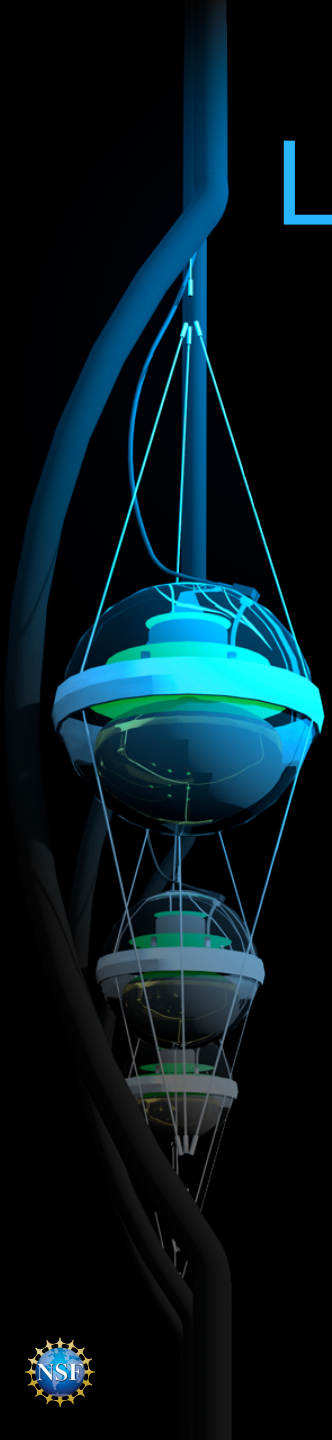
- 250 people
- 39 Institutions
- 11 Countries
- Exotic Locales

The IceCube Neutrino Observatory



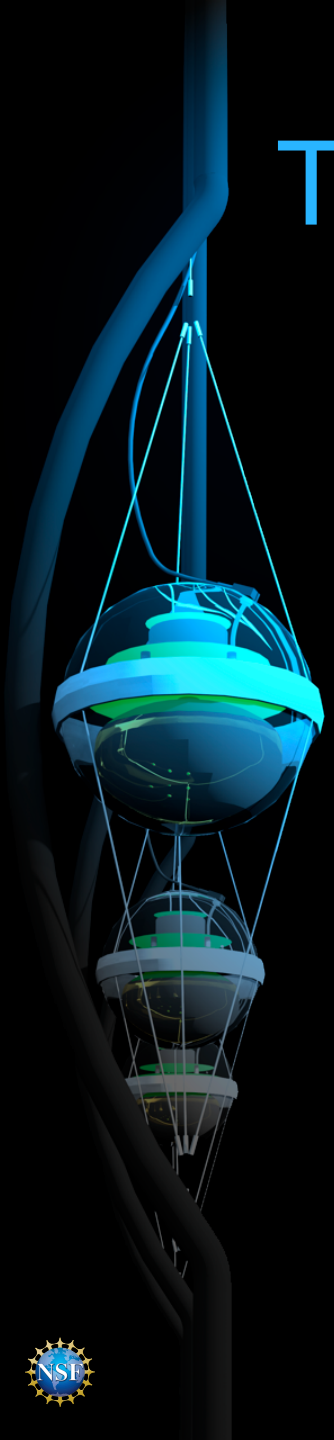
- A kilometer scale neutrino detector
- Located at geographic South Pole
- Detects Cherenkov light from neutrino interactions
- Sensitive to energies down to about 10 GeV

Location, Location, Location



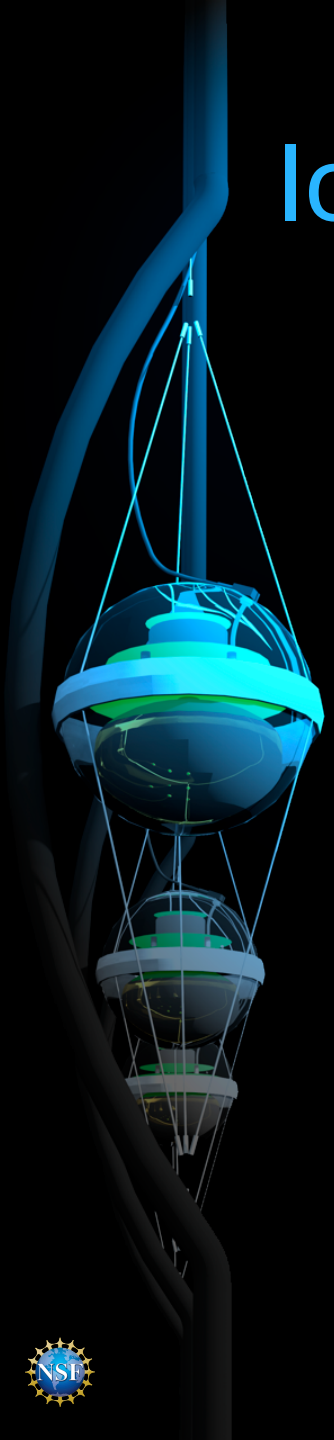
- Why the South Pole?
- Lots of ice – a great detection medium
- The ice is very clear
- Thick ice sheet – sensors deep enough to provide significant background reduction

The Detector(s)



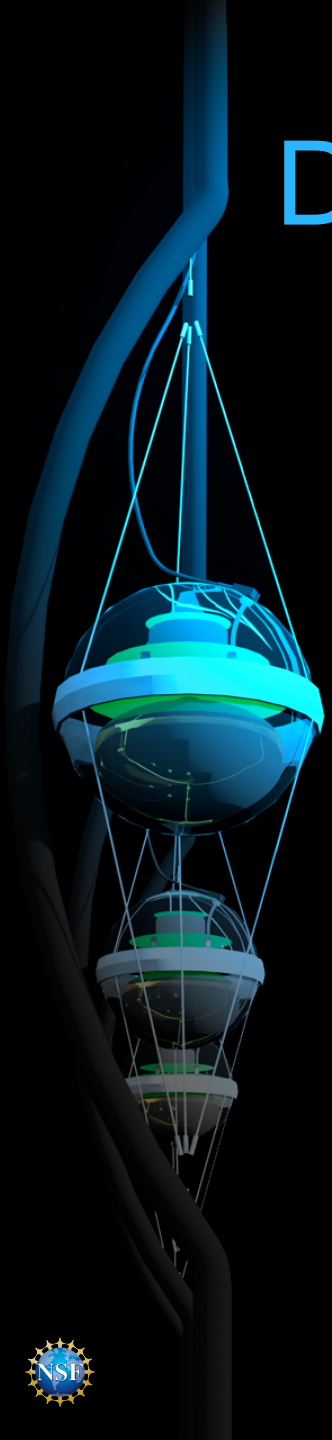
- Actually three detectors
  - IceCube baseline detector – 100 GeV
  - IceTop air shower array – 300 TeV
  - DeepCore extension – 10 GeV

IceCube Baseline Configuration



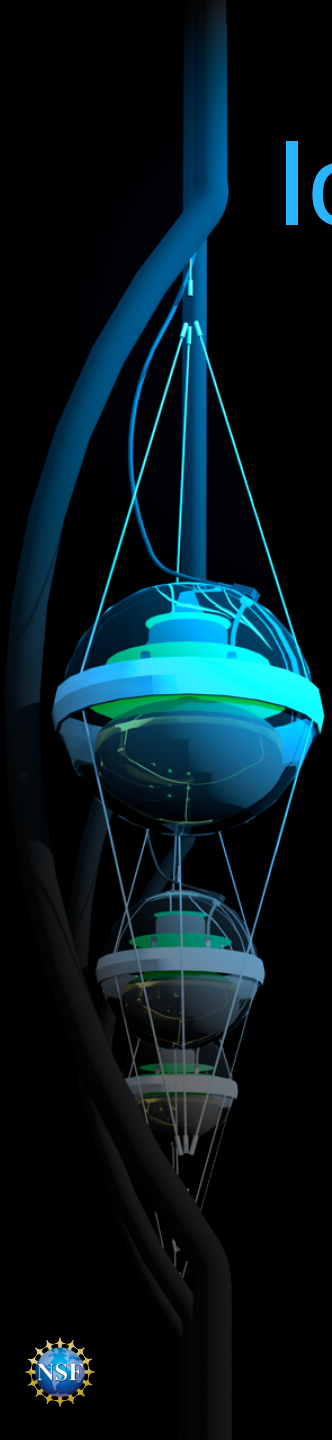
- Digital Optical Modules (DOMs) - Photomultiplier Tubes and supporting electronics
- Deployed on 80 vertical strings, each with 60 DOMs
- Spaced out on a 125 meter grid covering 1 km^2 on the surface
- Vertically, 17 meters apart at depths between 1450 and 2450 meters

DeepCore extension

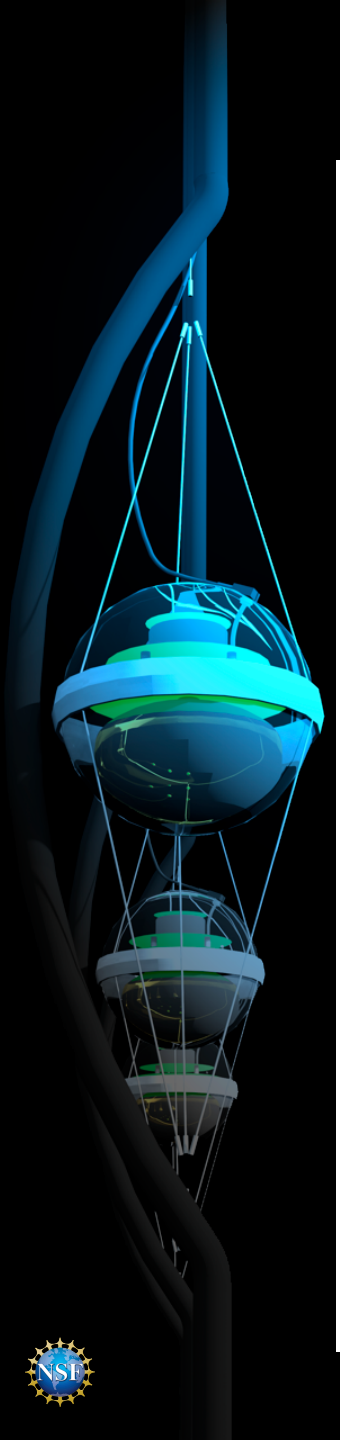


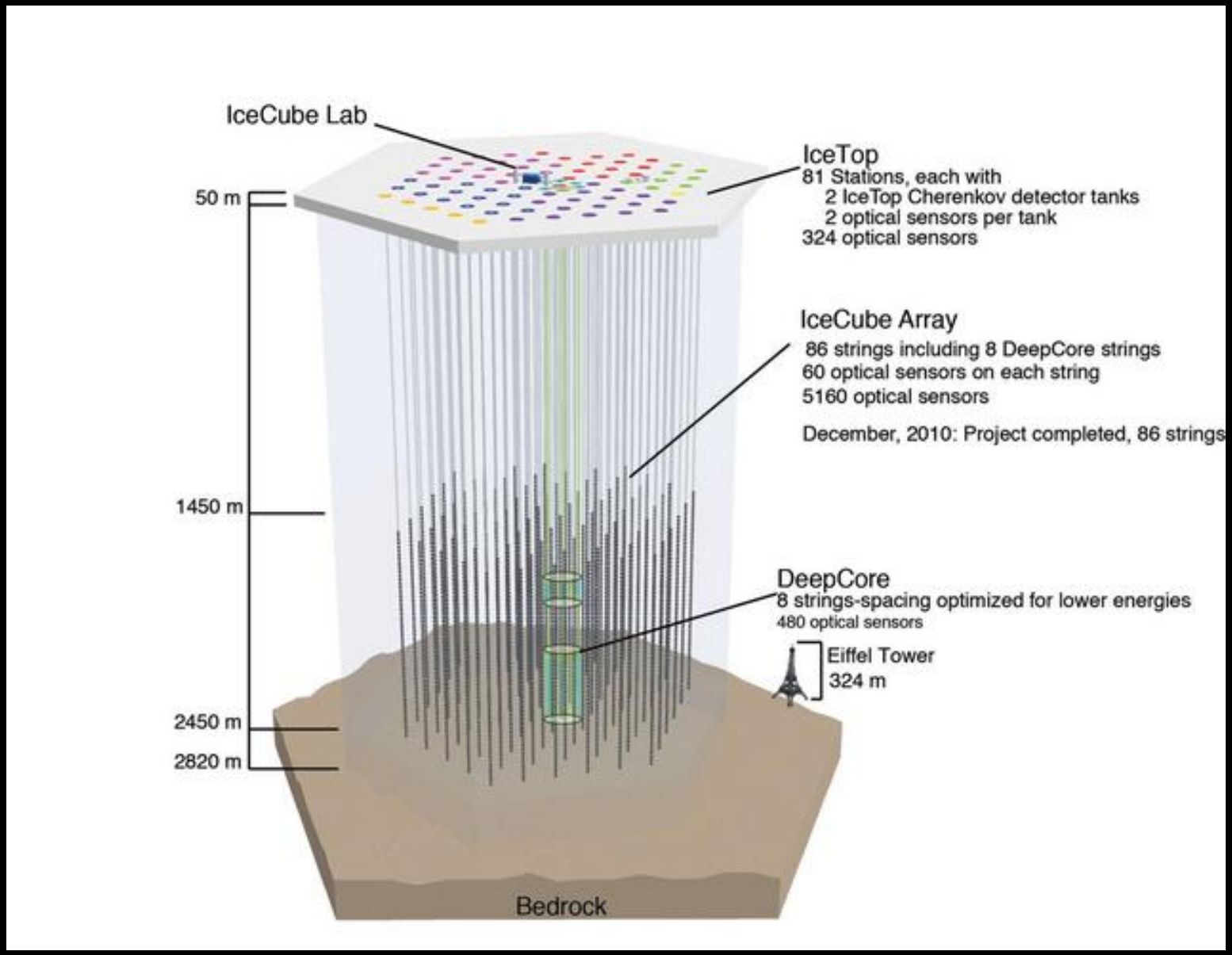
- Six additional strings beyond baseline
- PMTs have higher quantum efficiency
- Tighter spacing
- Extends energy sensitivity down to about 10 GeV

IceTop Air Shower Array

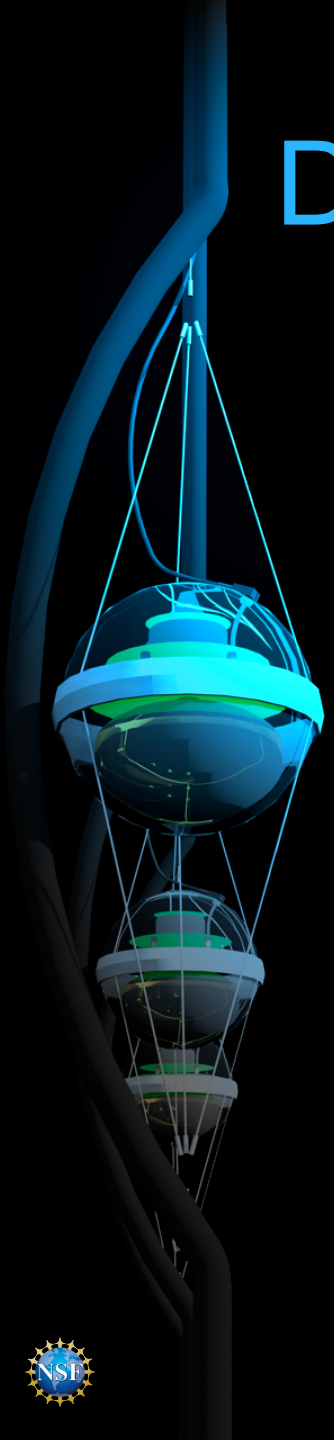


- 160 tanks filled with ice
- 2 DOMs per tank
- 2 tanks spaced 10 meters apart at the top of 80 baseline strings
- Used for study of cosmic ray air showers
- Sensitive to 300 TeV

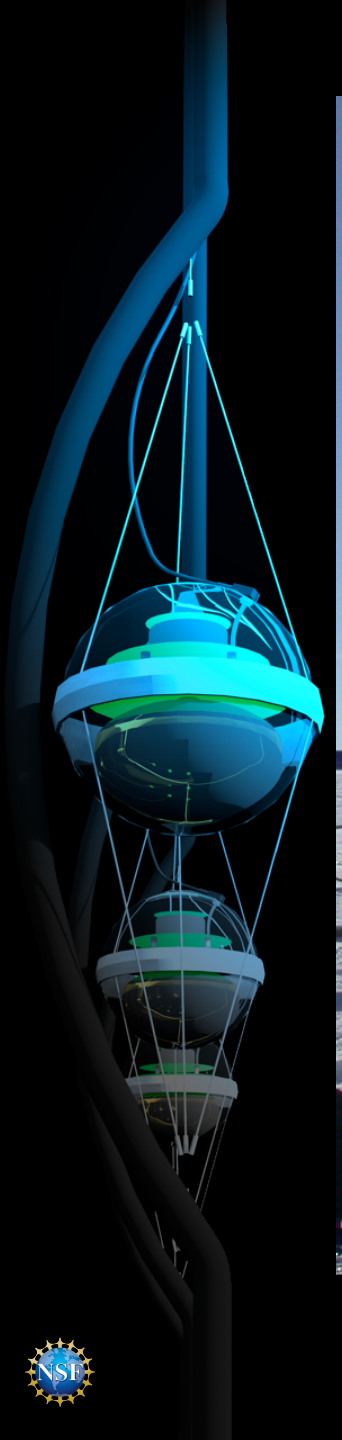


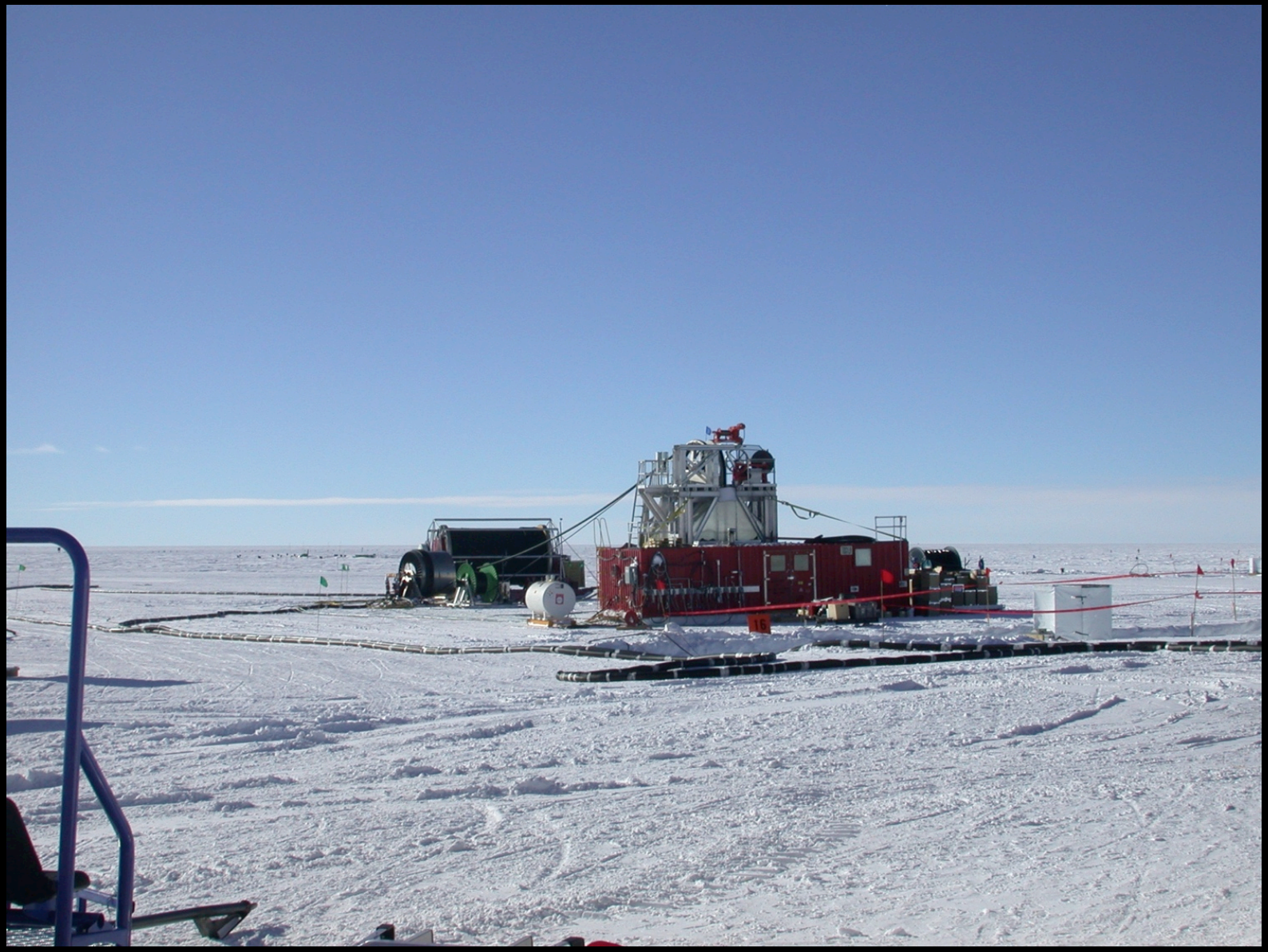

IceCube Lab
IceTop
81 Stations, each with
2 IceTop Cherenkov detector tanks
2 optical sensors per tank
324 optical sensors
50 m
IceCube Array
86 strings including 8 DeepCore strings
60 optical sensors on each string
5160 optical sensors
December, 2010: Project completed, 86 strings
1450 m
DeepCore
8 strings-spacing optimized for lower energies
480 optical sensors
Eiffel Tower
324 m
2450 m
2820 m
Bedrock

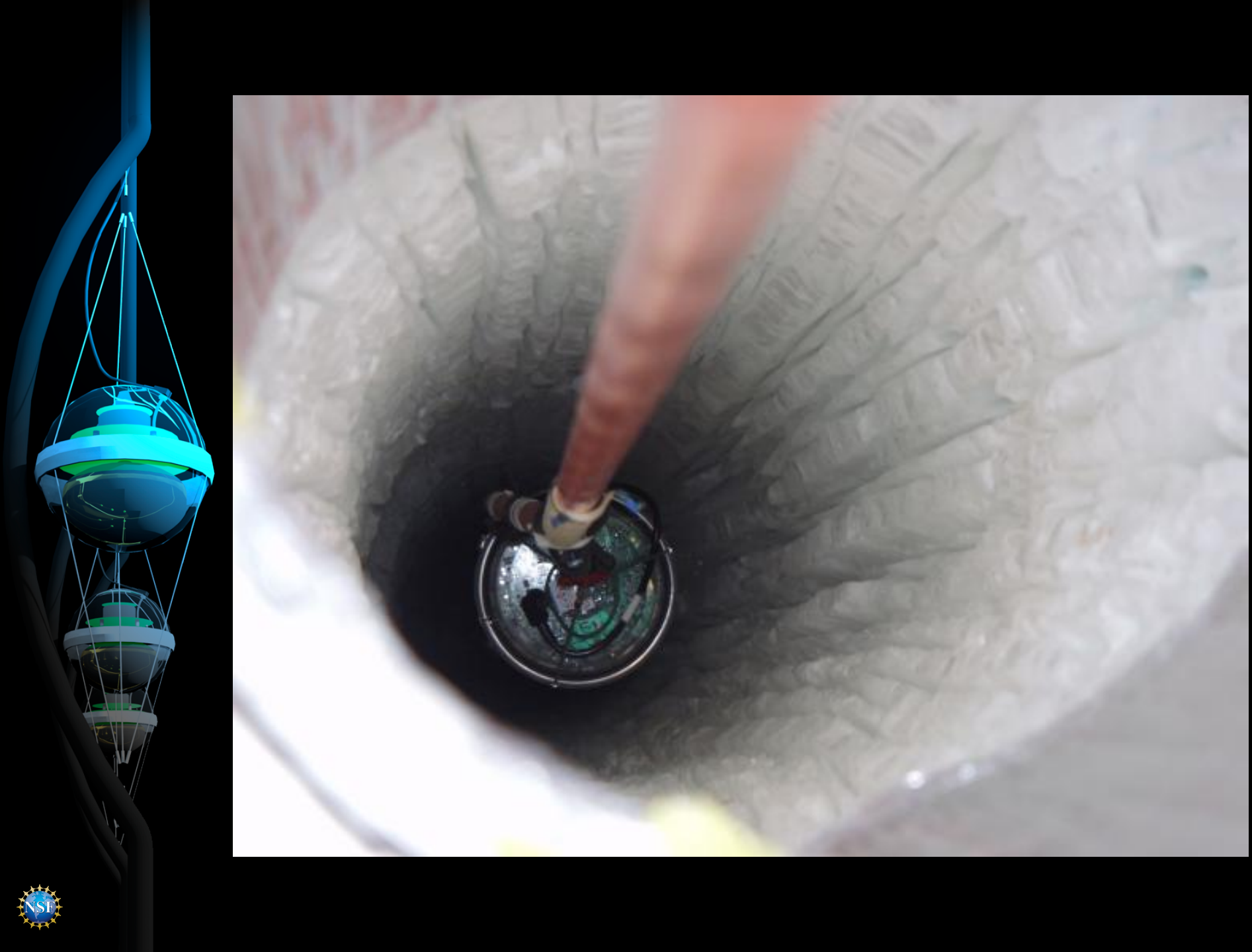
Drilling and Deployment



- Hot water drill with ~5 MW output
- Drilling takes 26-30 hours per hole
- Strings deployed in ~ 20 hours
  - DOMs get final test
  - Attached to surface cable
  - Lowered into hole
- About 1 month to completely re-freeze

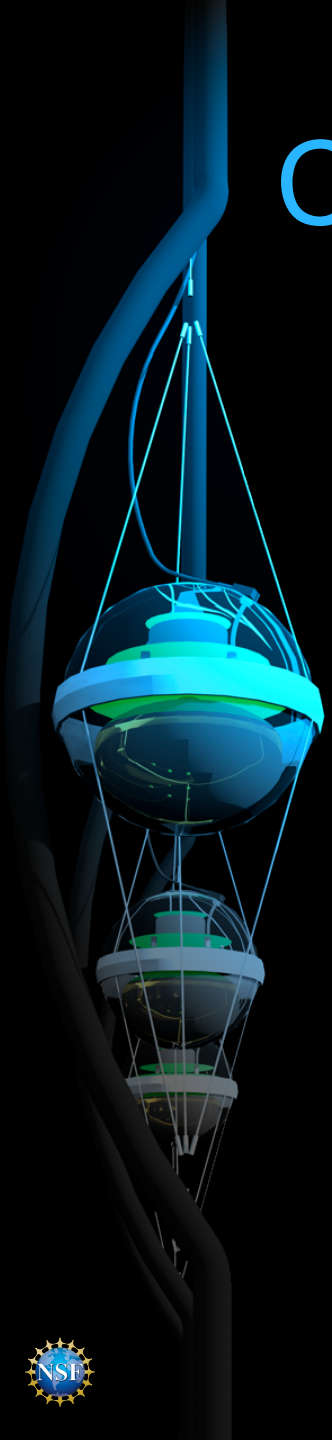



16

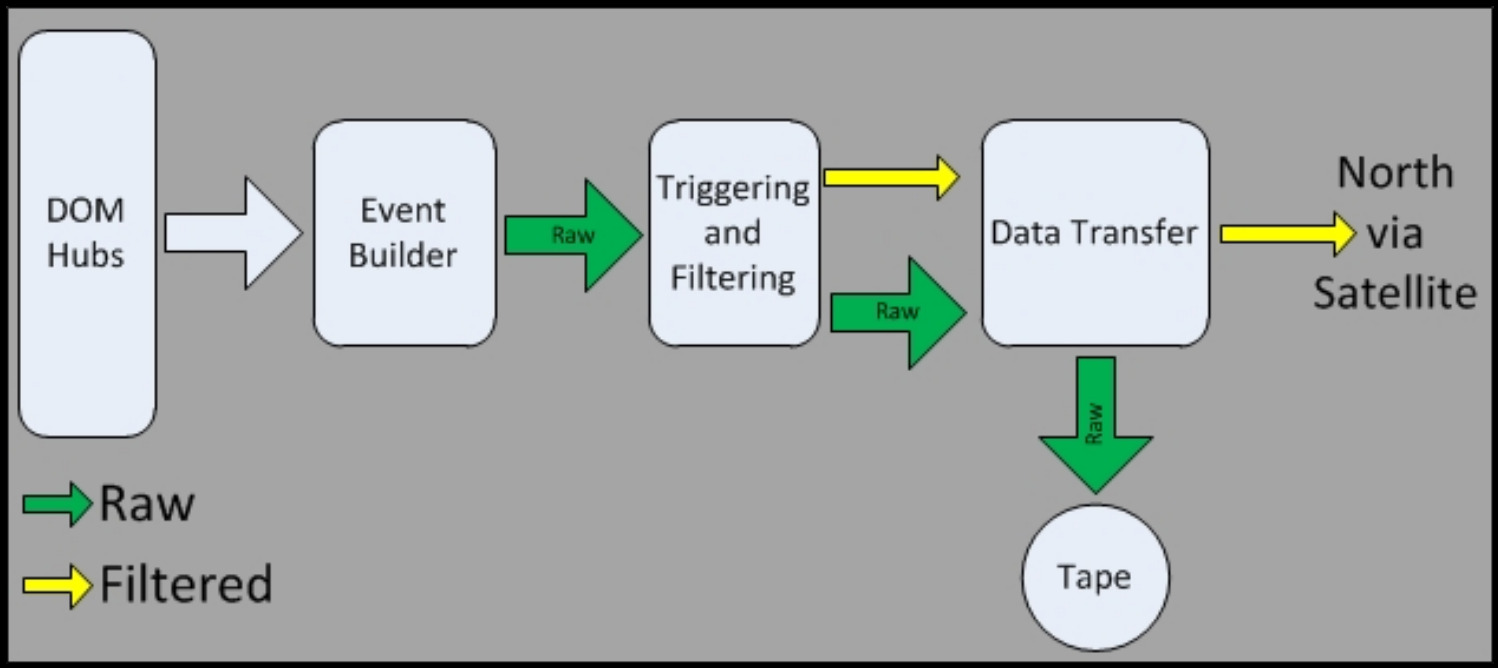


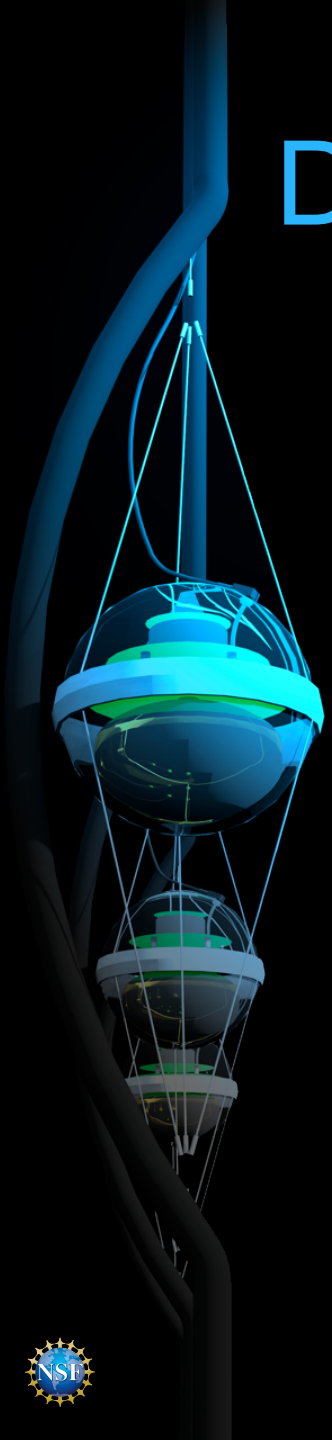
Construction is complete

- First string deployed in 2004-2005 season
- Detector completed in 2010-2011 season.



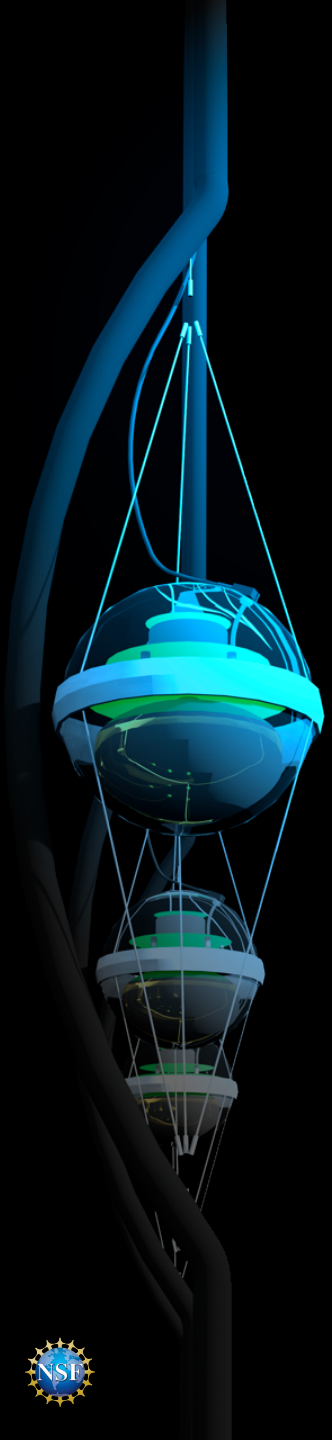
Online Processing



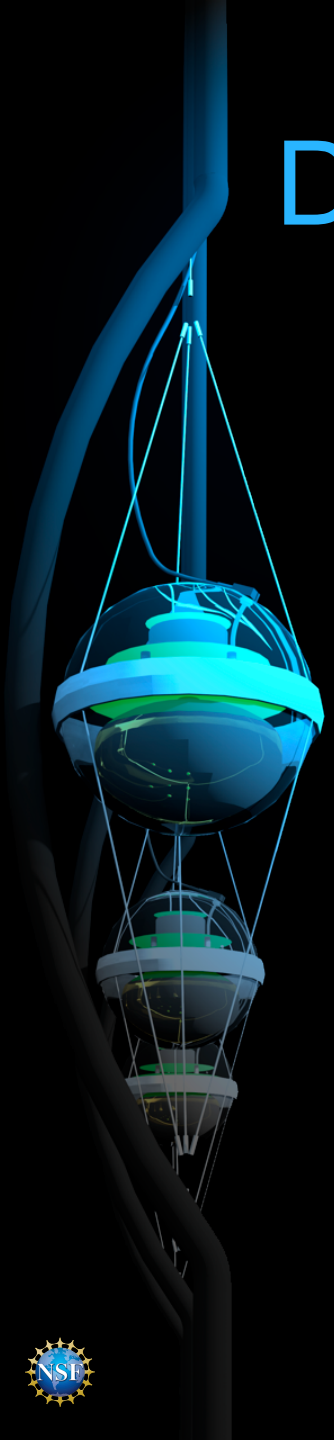


Data Volume

- Event rate of 3000 Hz
- 1 TB/day raw data
- Reduced to 105 GB/day
  - Based on available satellite bandwidth
- Tapes shipped North every year

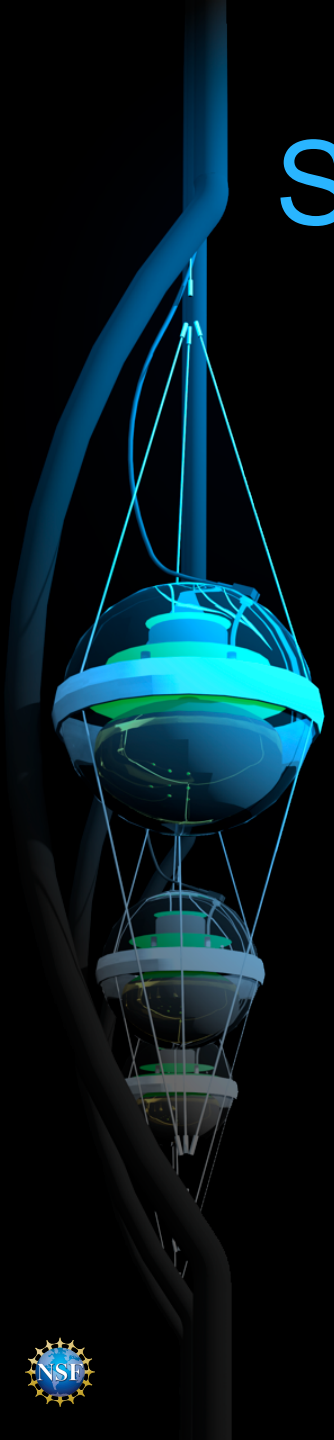


The North



Data Production

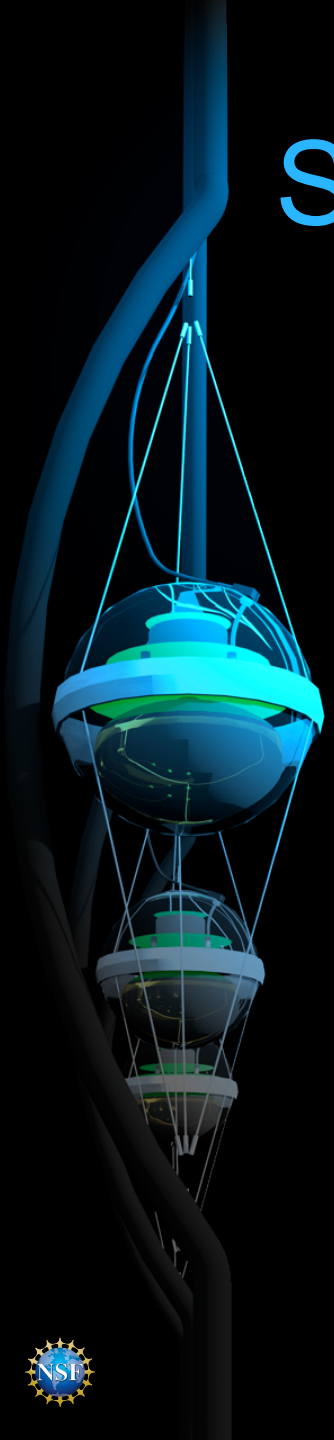
- Level 1
  - Filtered stream from Pole
- Level 2
  - Basic path reconstruction of upgoing muons
  - Good reconstructions of downgoing muons
  - Deal with coincident muons
- Level 3 – set by each working group
  - Event selection
  - Stream separation



Simulation

- Event generation
  - CORSIKA for cosmic ray background
  - Several neutrino generators
- Photon propagation
  - Lookup tables
  - Direct simulation on GPUs
- Detector simulation

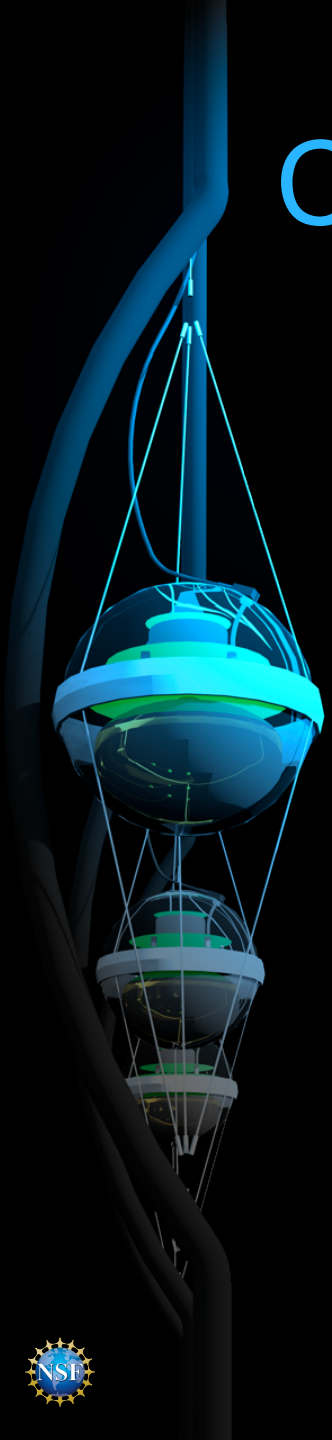
Simulation Framework



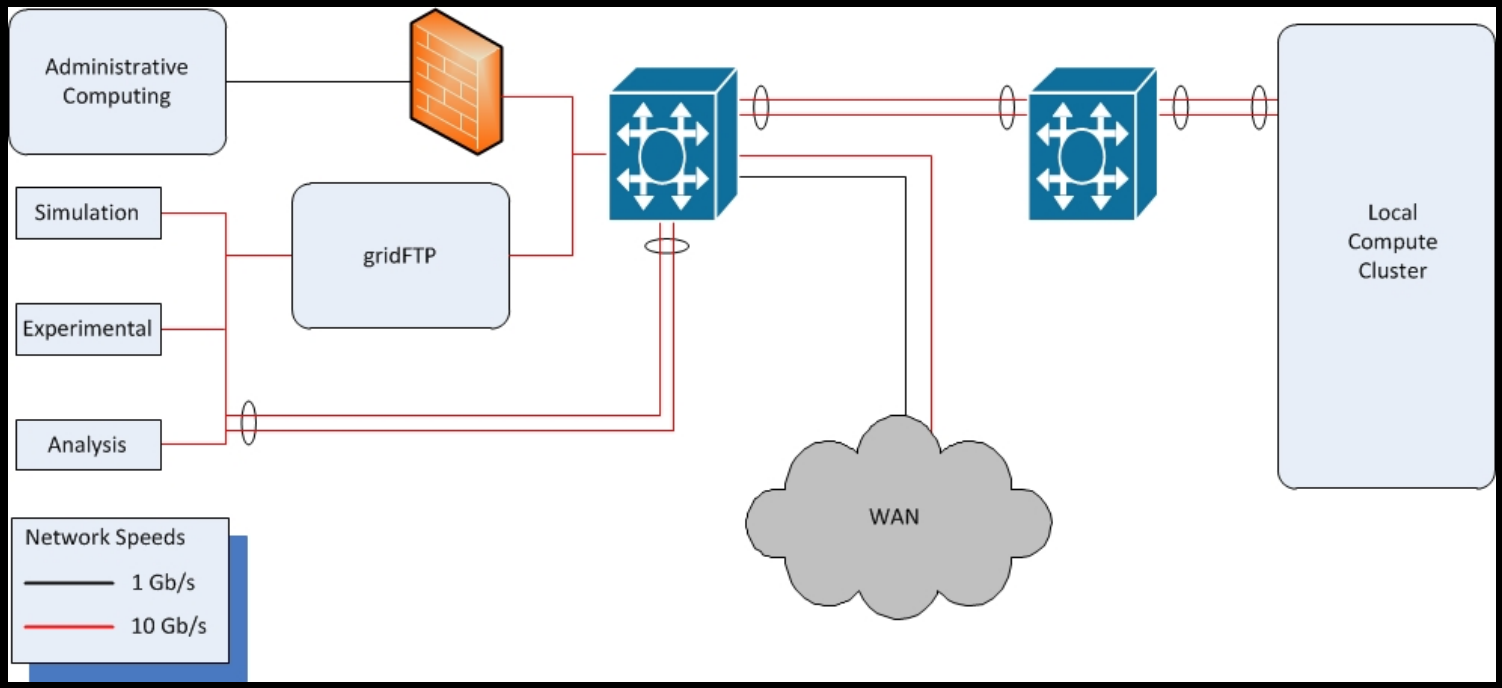
- Software framework to coordinate components
- Central DB at UW-Madison to coordinate and track production
- First versions were monolithic – photonics tables made grids difficult
- Newer versions broken into finer steps

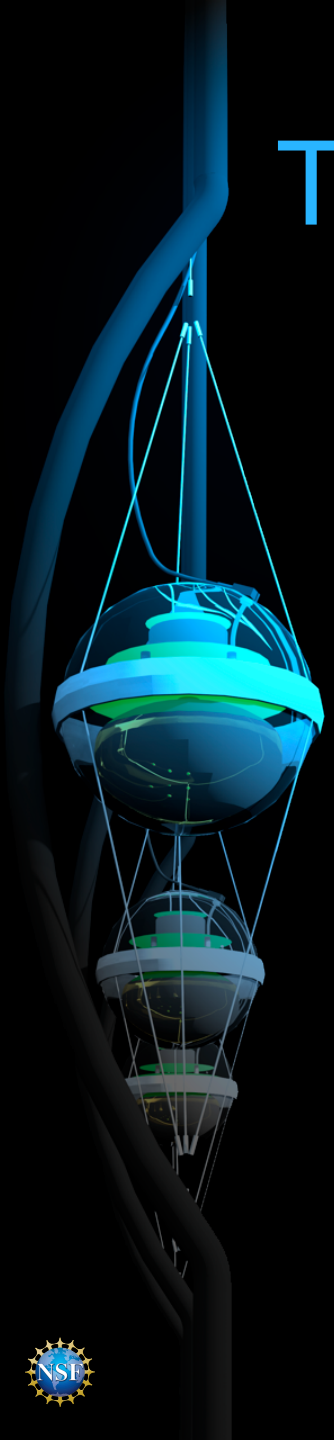
Computing Model

- University of Wisconsin - Madison – Tier 0
  - Raw data collection and archive
  - Data production to Level 3
  - Coordinate simulation production
- DESY-Zeuthen – Tier 1
  - Second copy of Level 2 data
  - Hold simulation data sets in Europe



UW Overview


Administrative Computing
Simulation
Experimental
Analysis
gridFTP
WAN
Local Compute Cluster
Network Speeds
1 Gb/s
10 Gb/s

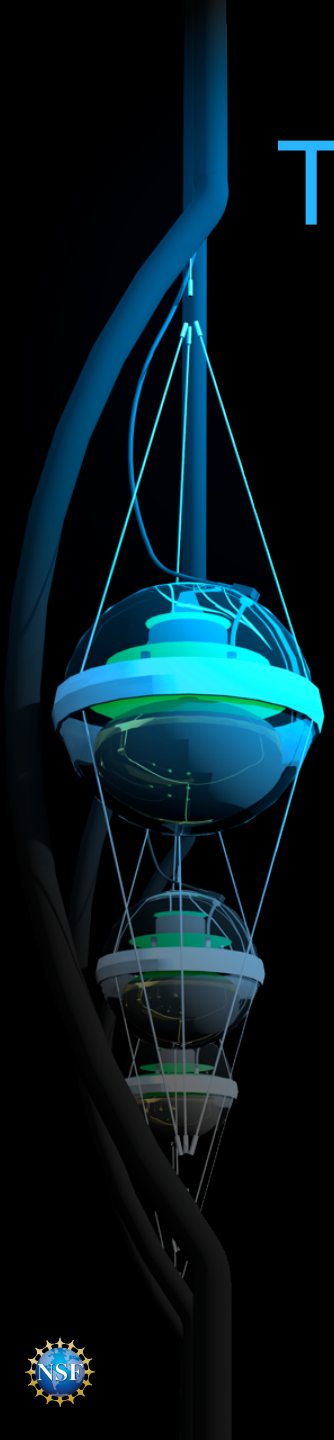


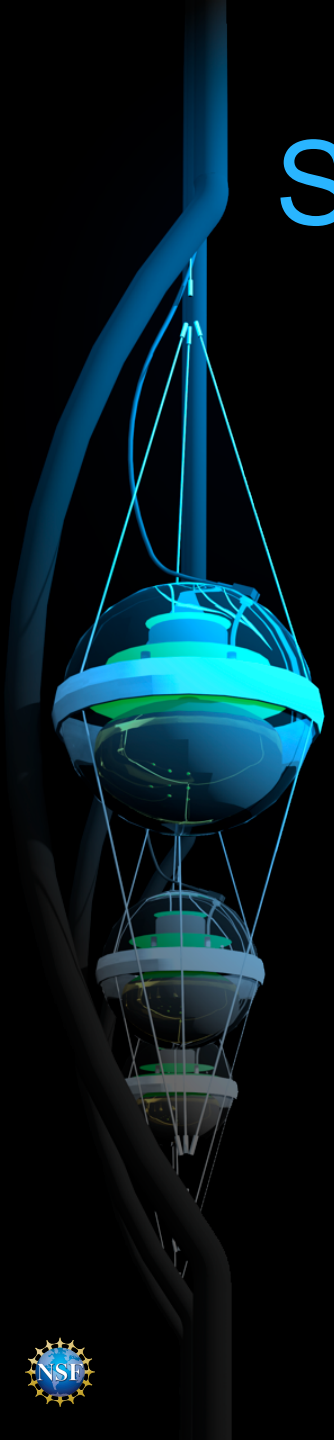
Tier 0 Capacity

- Compute cluster
  - 1200 cores, at least 2 GB/core memory
  - Approximately 16,000 HEPSpec06
- Experimental data
  - 1 PB Lustre filesystem
- Simulation data
  - 1.2 PB Lustre filesystem
- Analysis data sets
  - 250 TB Lustre filesystem

Tier 1 Capacity

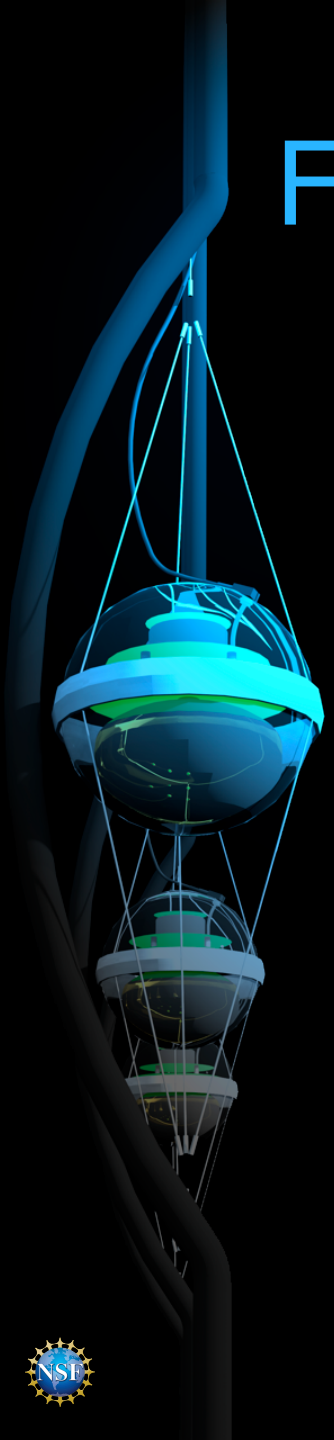
- Grid CPU
  - 384 cores
  - Approximately 6300 HEPSpec06
- Storage
  - 360 TB dCache
  - 150 TB Lustre
- Local CPU
  - 1000 cores
  - Approximately 13,800 HEPSpec06





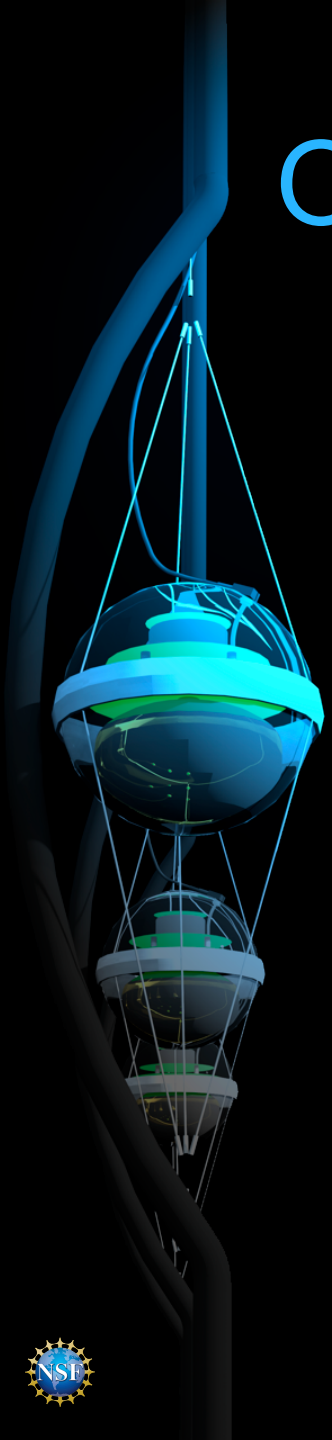
Simulation Production

- Driver of our distributed computing
- Collaboration institutions contribute to simulation production
- Production is coordinated with a central DB at UW Madison
- Output is collected at either DESY-Zeuthen or UW Madison



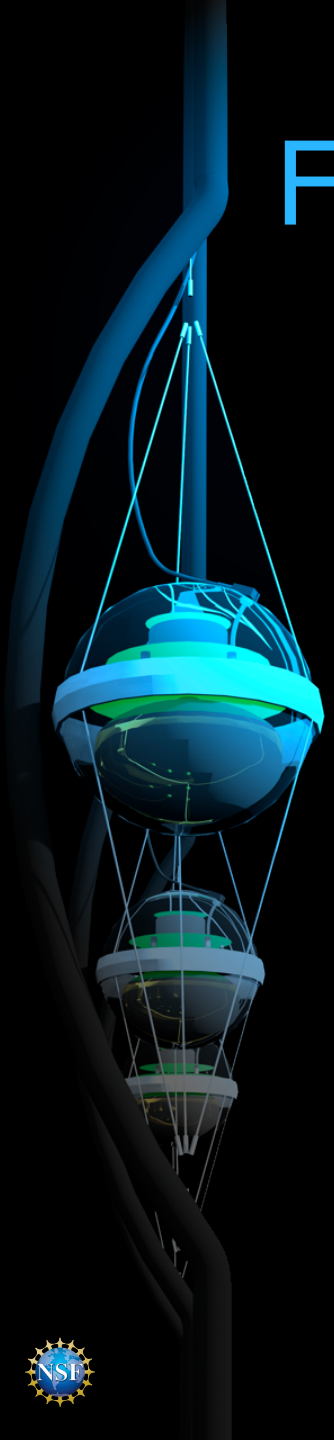
Feeding the Grids

- US institutions
  - Tend to be local institution resources
  - Otherwise OSG resources
- European institutions
  - LHC grid resources
  - Regional grid resources
- GridFTP – lowest common denominator



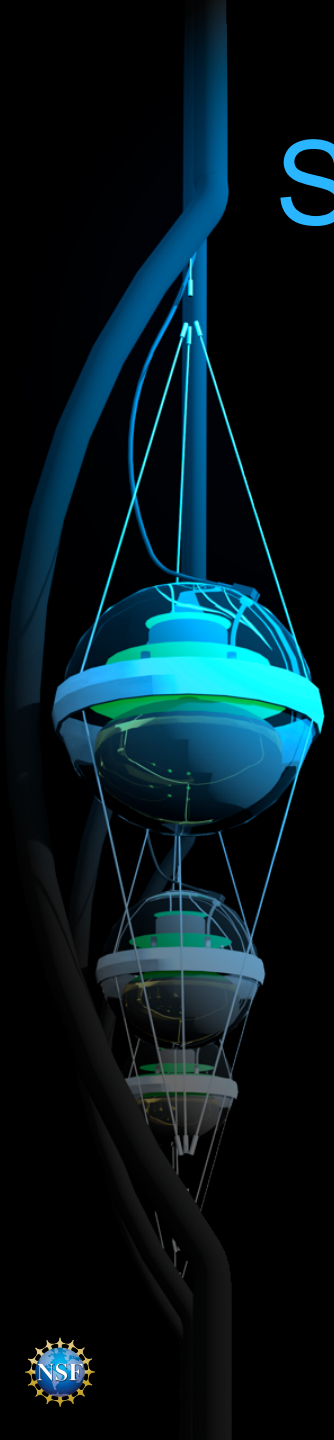
Organizational Keys

- Tier 0 – own and operate resources
- Good partner – DESY-Zeuthen Tier 1
- Good collaborators
- Great UW campus network group
  - Flexible
  - Committed to supporting research



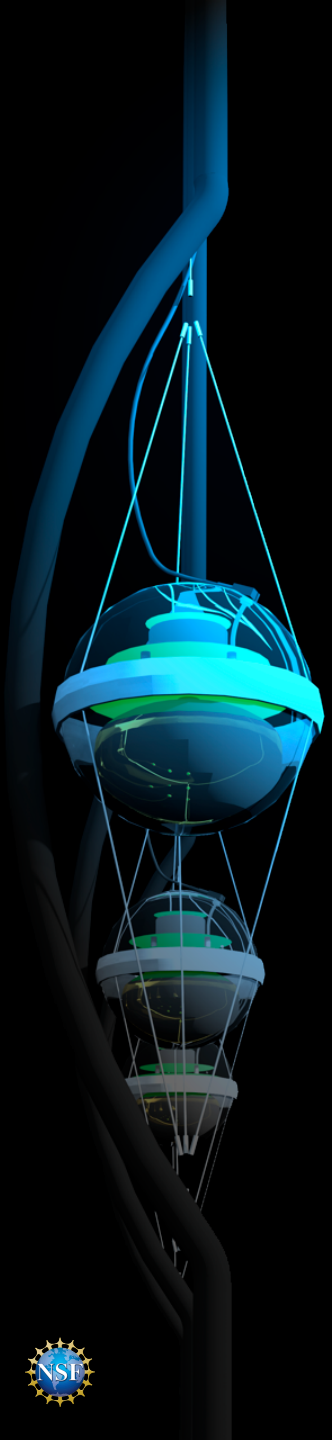
Future

- Rainbows and unicorns from here?
- Storage
  - Storage management – scaling
  - Data management – scaling
  - Data movement
- Computing
  - Stronger GPU emphasis
  - Better grid integration
  - Clouds?



Summary

- IceCube is a km scale neutrino detector
- Can make good use of dramatically scaled down LHC techniques
- Good partners and good collaborators smooth the path
- We may not be the coolest experiment on the planet, but we are one of the coldest.



Questions?